Formation, Degradation, and Treatment:

Addressing water quality challenges in Salem's Aquifer Storage and Recovery Wells

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Engineers...Working Wonders With Water®

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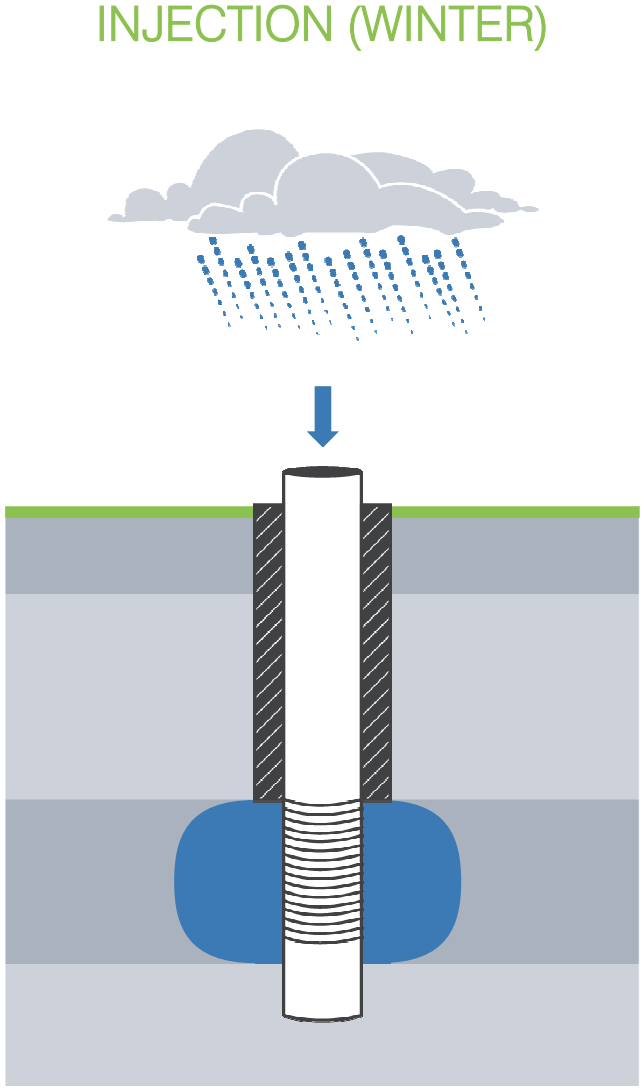
ASR is an underground reservoir

ASR reallocates water by storing it when it is abundant for use later when it is needed most.

- Water is collected and stored underground in the winter when precipitation is plentiful and demands are lower (injection)
- Water is pumped out in the summer when demand is high and surface water sources are strained (recovery)



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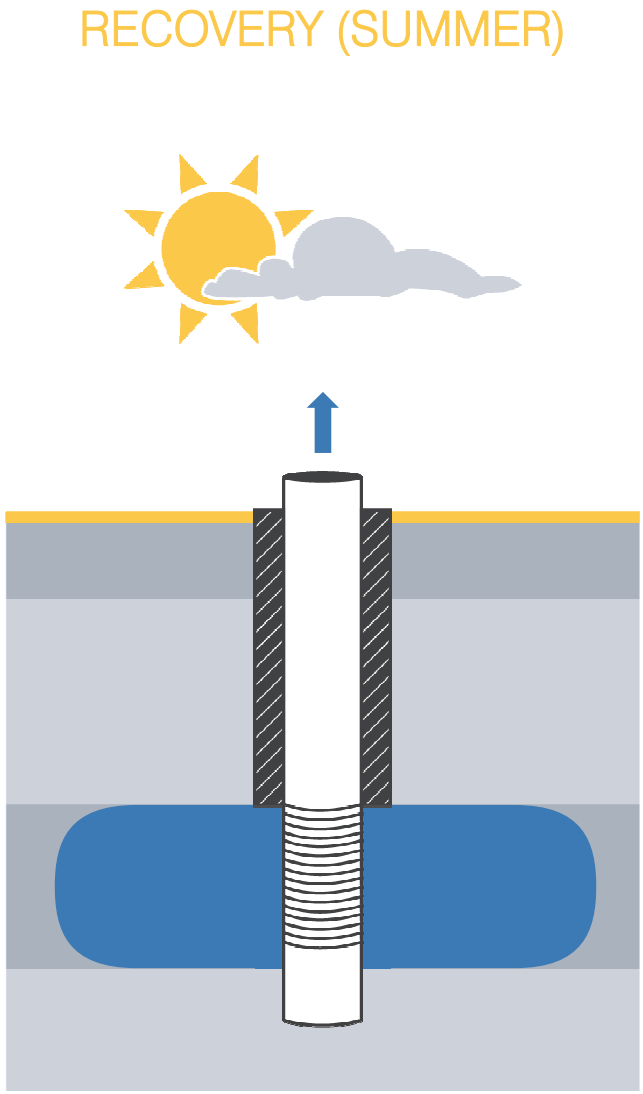

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Salem's ASR

Santiam River →
Woodmansee Park

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Salem's ASR

- Source: treated Santiam River water
- Aquifer: Columbia River Basalt
- 1st ASR limited license issued in Oregon (1997) Allows for:
  - Max storage volume: 1 billion gallons
  - Max recovery rate ~20 MGD from up to 15 wells
- Current system:
  - 4 wells, average recovery ~5 MGD
  - Max storage volume to date 695 MG (2018)
  - Peak summer demands
  - Turbidity events

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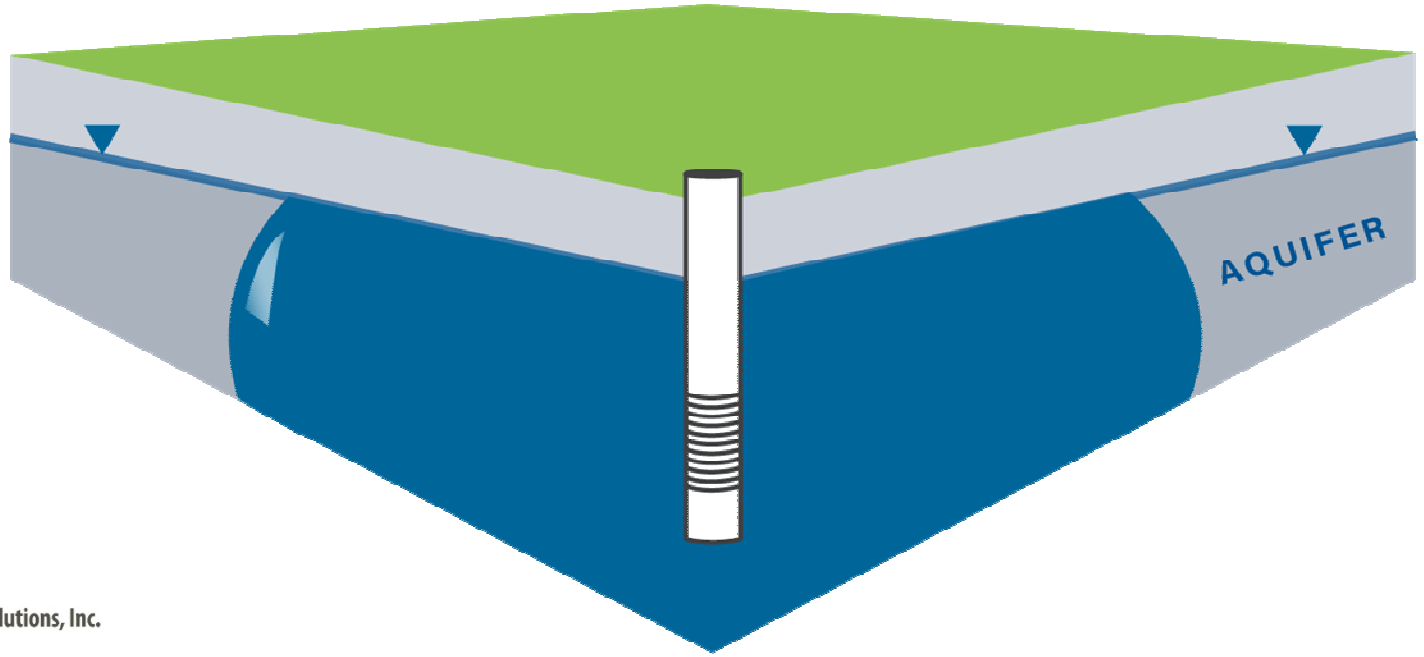
ASR and Water Quality

Chlorinated surface water + basalt rock + native groundwater + time = Recovered water quality



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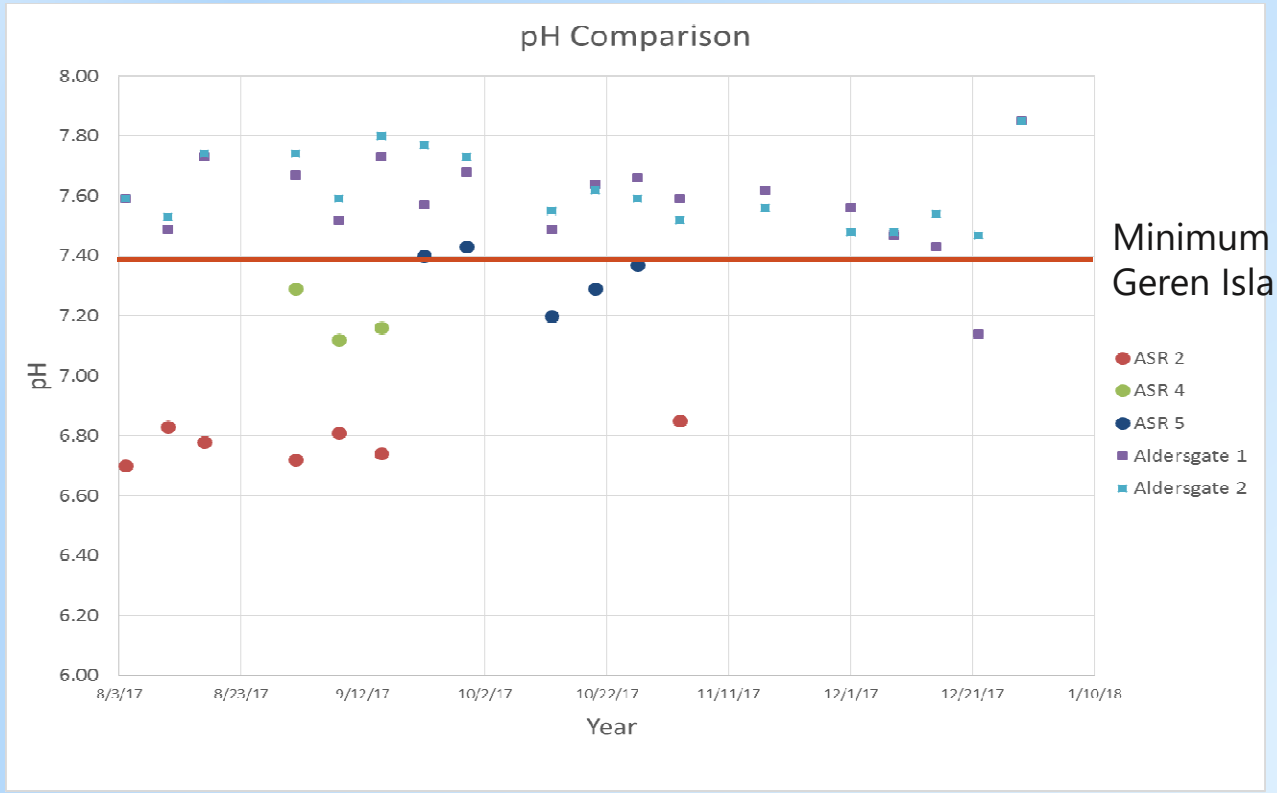
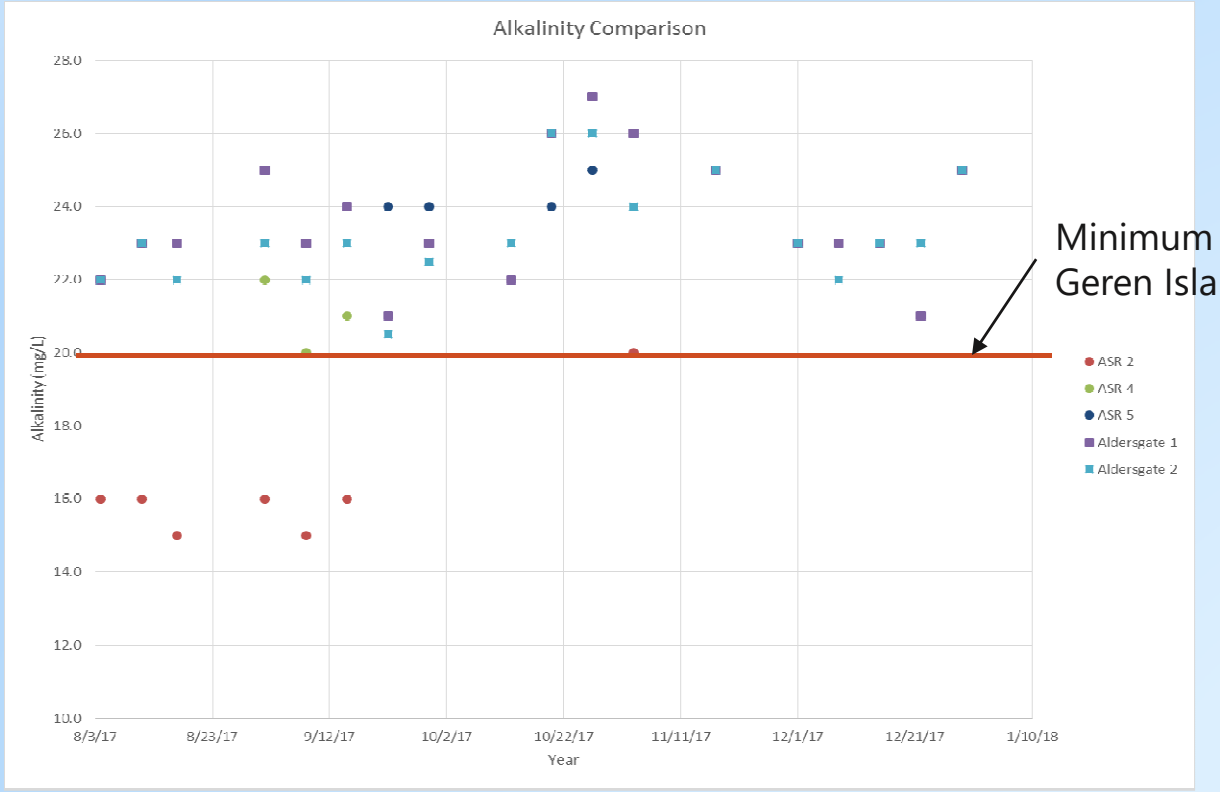
WQ Challenges

pH: Recovered water pH is lower than source

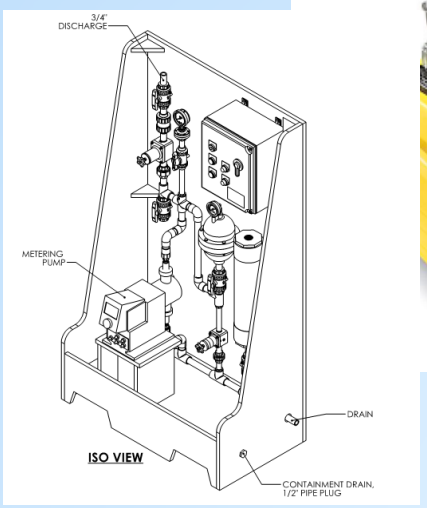


Minimum pH from Geren Island

Alkalinity: Recovered water alk is lower than source



Options for pH and alkalinity adjustment included soda ash and caustic soda.



Operations and Maintenance	
Soda Ash	Batching system + pumps
Caustic Soda	Tote + metering pumps

Building size and cost were important factors in the selection.

	Soda Ash	Caustic Soda
Building Impacts		
Footprint	Batching system has larger footprint or requires taller building	More compact
Classification	Not hazardous	> 500 gallons will make building H-4 (sprinklers and access considerations)
Chemical Delivery	Stored as power – needs to be stored in dry room	Requires contained storage
Chemical Handling	2000 ton bags on pallets	275 or 330 gallon totes on pallets
Cost		
Equipment	$65,000 - $150,000 for batching equipment $250,000 for complete system	$20,000 for pumps & VFDs $10,000 for pump accessories $15,000 for tote accessories
Chemical	$0.28 - $0.55 /lb delivered	

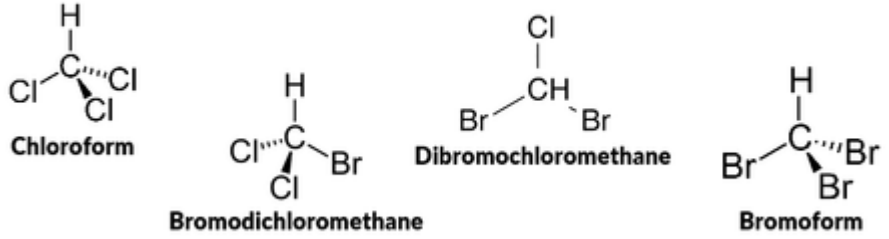
DBPs: Recovered water sometimes had high levels of DBPs

Disinfection-by-products are formed by chlorinating organic matter.

Impacted by:

- TOC concentration & reactivity
- Chlorine residual concentration
- Contact Time
- pH

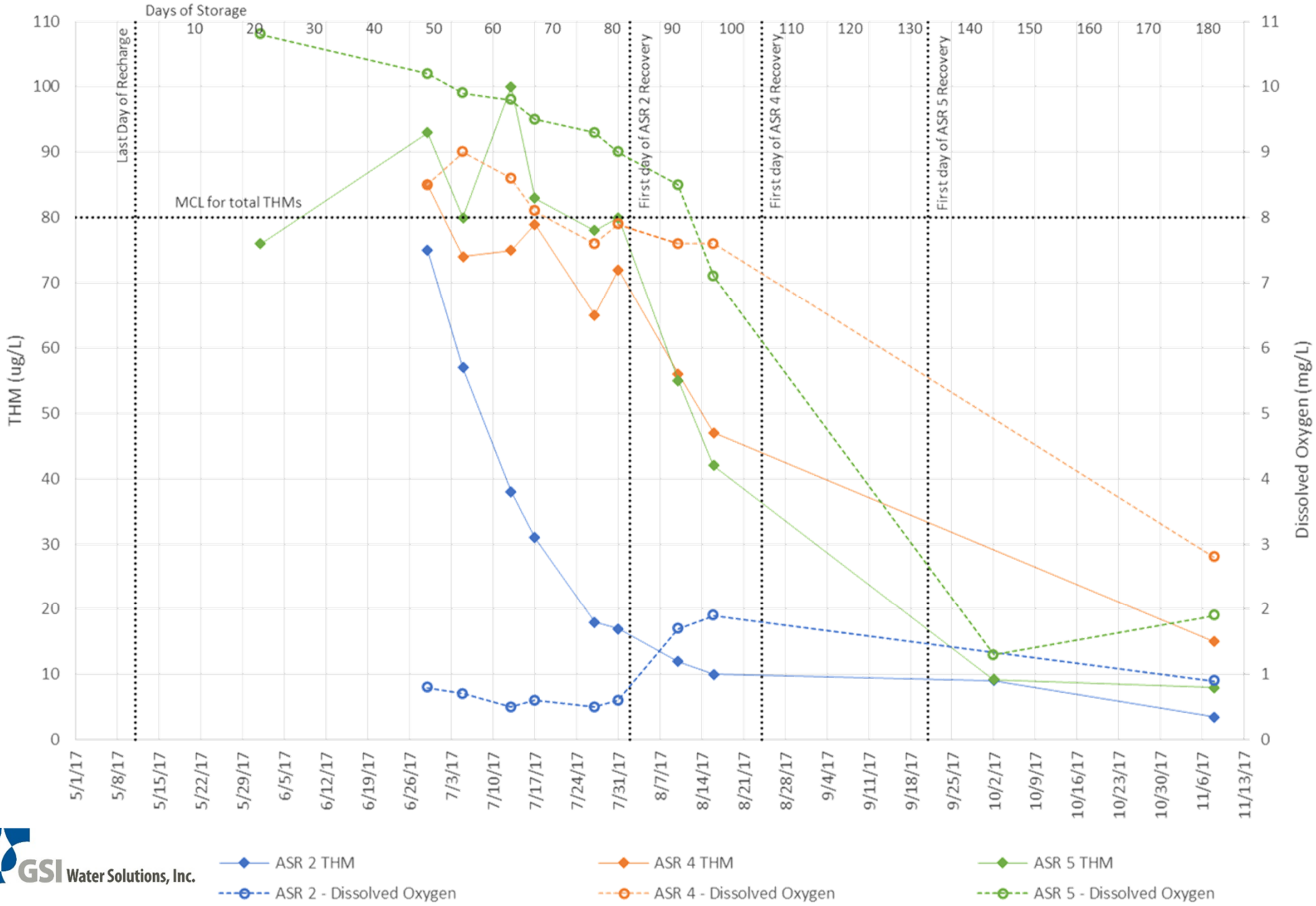
Total Trihalomethanes (TTHMs)



DBPs: How a monitoring plan can shape operations

- First hits above MCL in 2005
  - City study → presented at ACE 2008
  - Correlation with storage volume → avoid carryover storage
  - Conc. declines during recovery pumping → pump to waste
  - Noted differences between wells → a mystery…
  - Started thinking about dechlorination
- Reasonable conclusions based on the data, but biased by the monitoring plan

DBP observations in 2017



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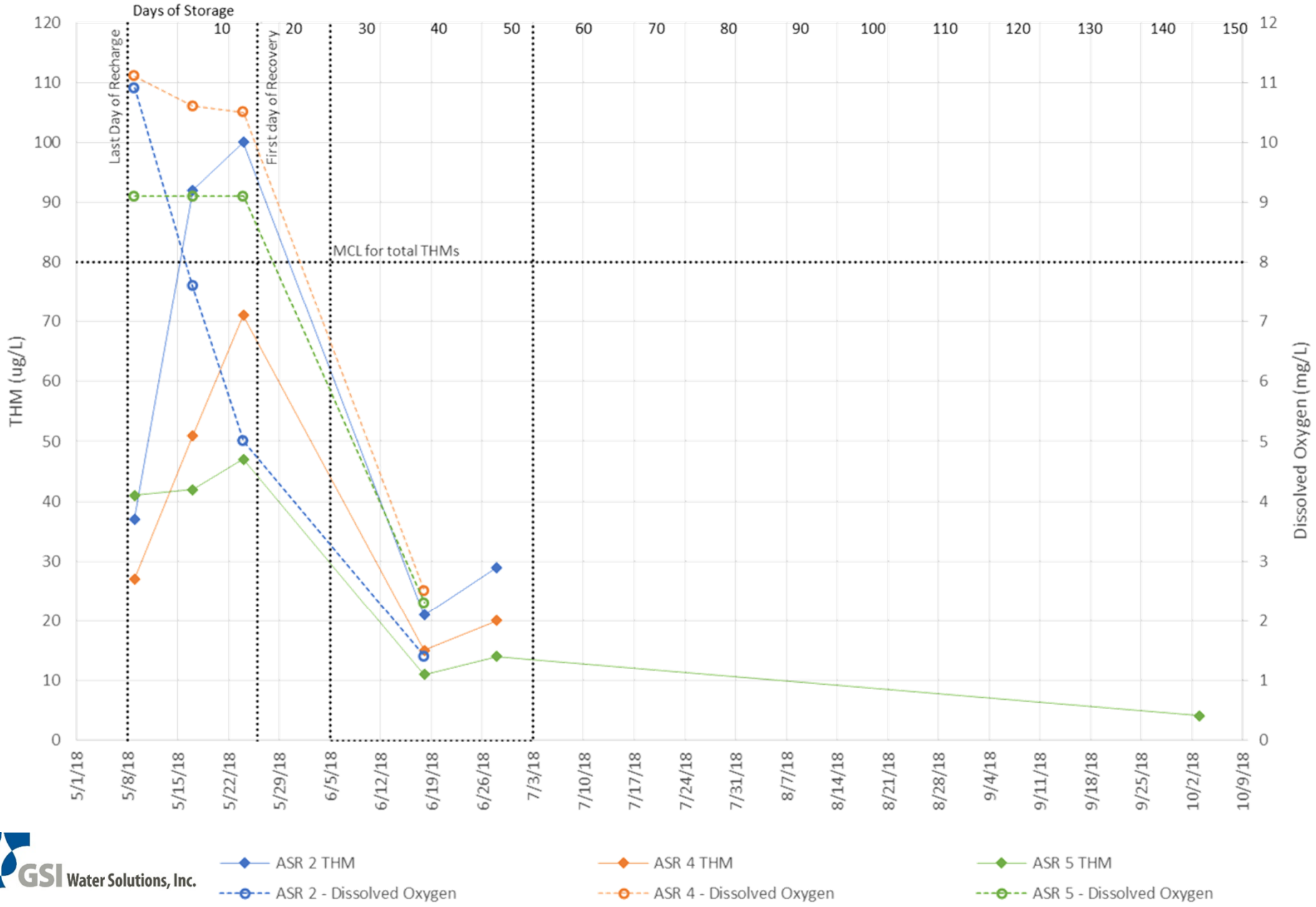
DBP observations in 2018



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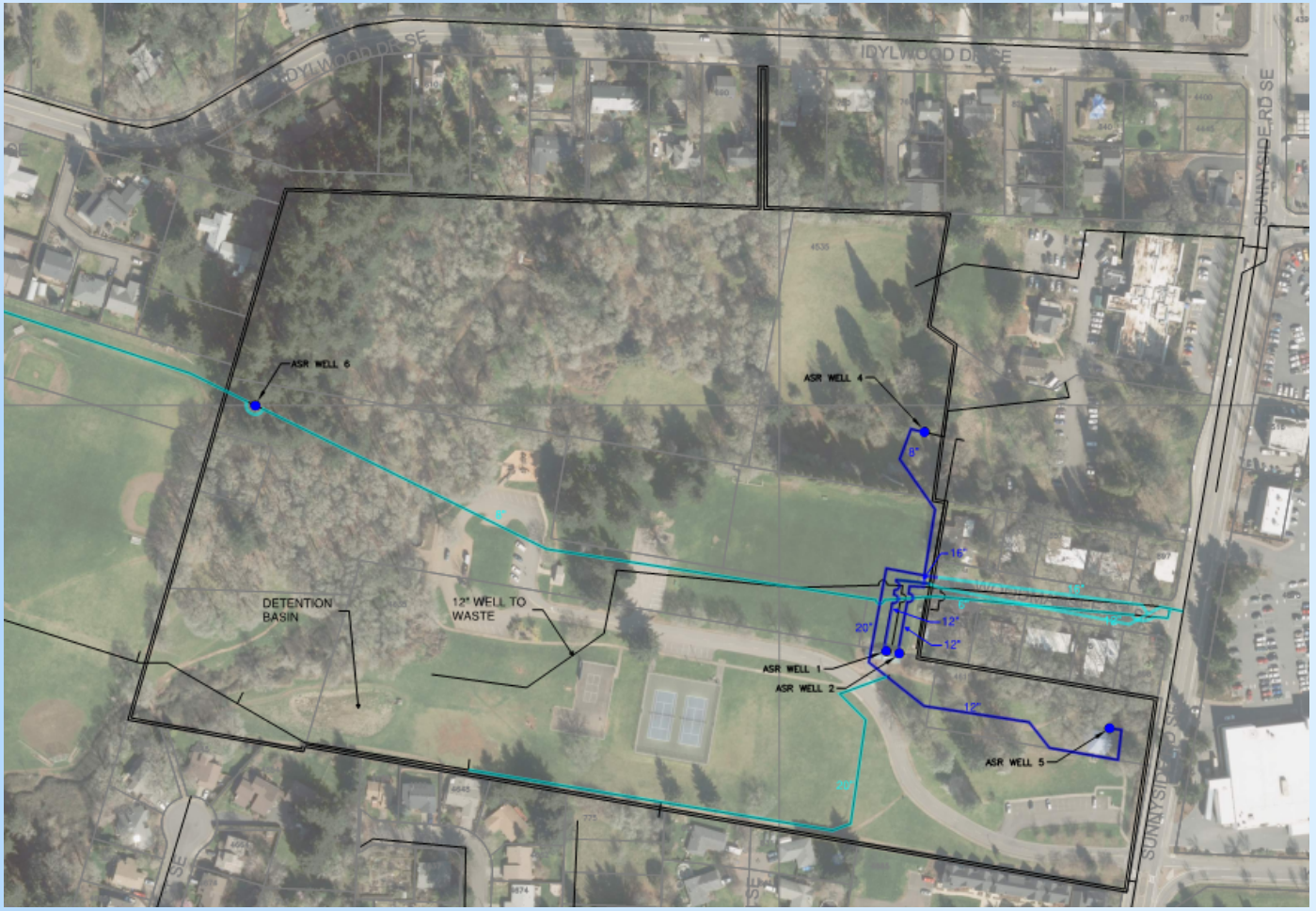
Current understanding

- Hits above MCL are more frequent and persistent
  - THM formation does not continue over long-term storage → don't fear residence time
  - Conc. declines over time → pump to waste is unnecessary
  - Noted differences between wells → preferential storage at ASR 2 → unintentional "aquifer conditioning"
  - Getting ready to implement dechlorination

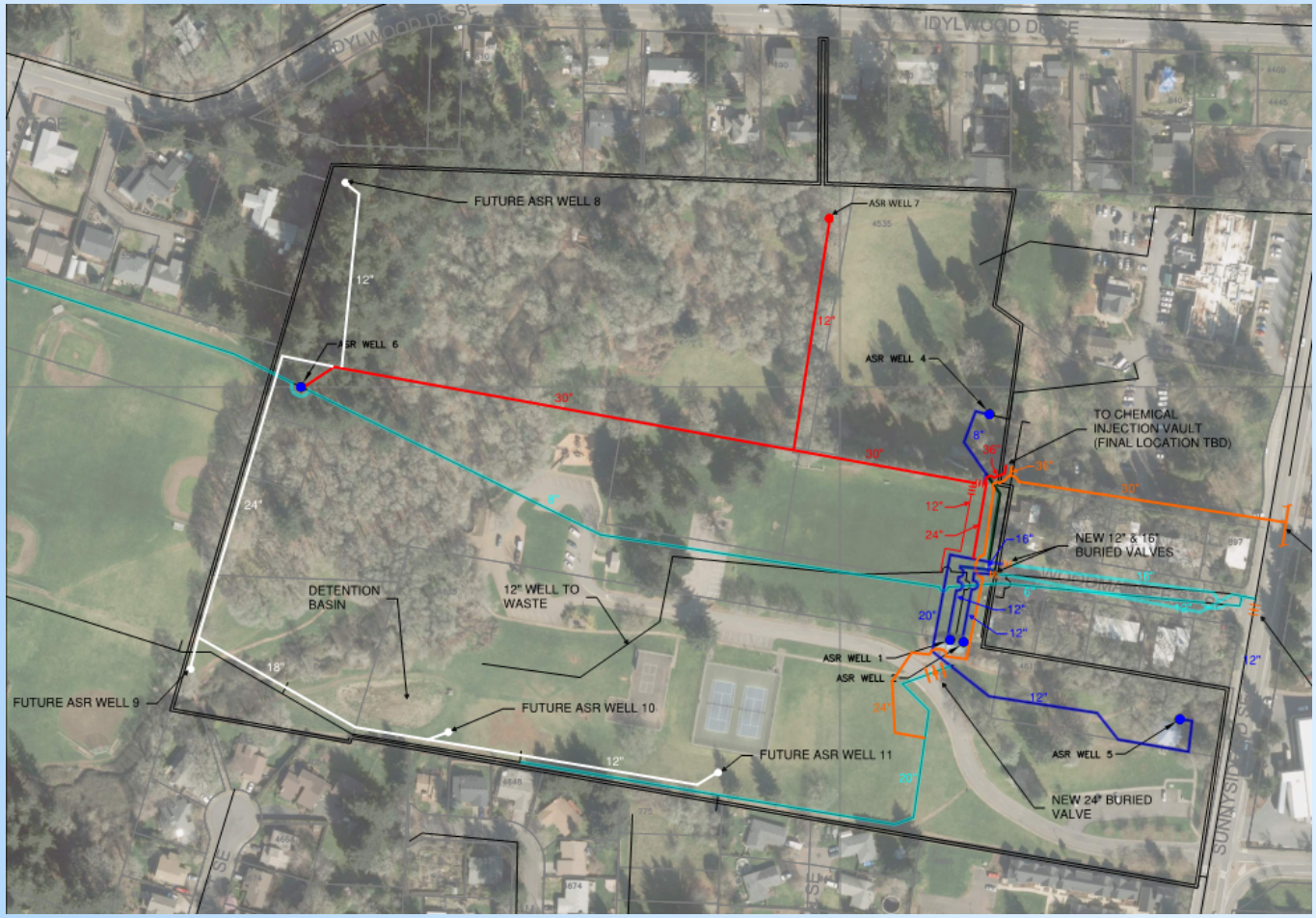
Facility Recommendations

Wanted: Single point of injection



- 3 connections to the distribution system
- Individual connections to the wells with distributed chlorination

Divide between “well” and “distribution”



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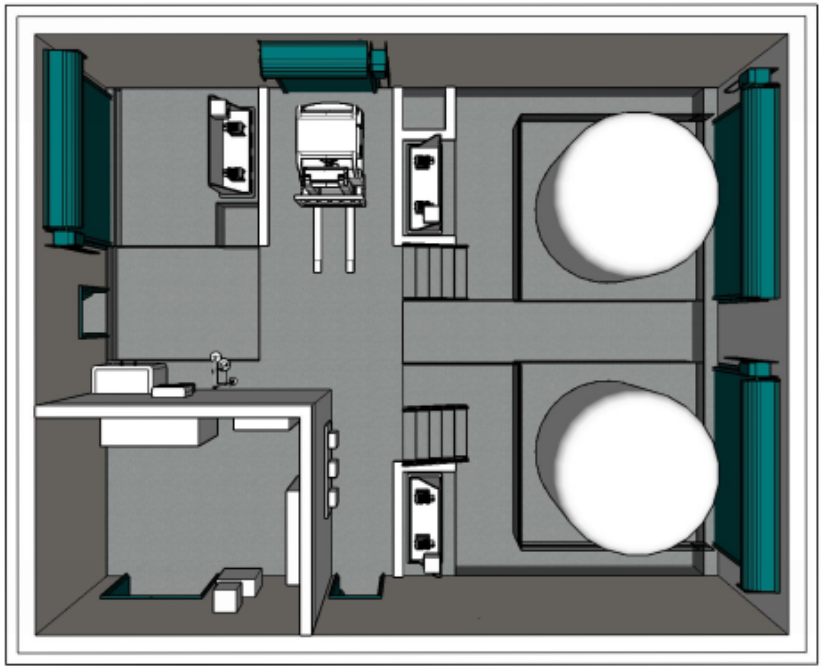
- Individual connections to the wells

Siting – Inside the park vs outside the park

Accommodating both low ave flow today and future higher flows

INTERIOR PERSPECTIVE

NTS



INTERIOR PERSPECTIVE WITH FUTURE TANKS

NTS

~40’x45’ footprint

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Questions?